**BENEFITS AND RISKS OF ADVANCED BIOTECHNOLOGY APPLICATIONS**

**BENEFITS**
- Misdiagnoses plummet and healthcare outcomes improve.
- Rapid, more effective medical treatments.
- Reduce delays and rejections of organ transplants and repairs.
- Major reduction in inherited genetic diseases.
- Improved speed and reliability in designing and making novel materials, medicines.
- Ready production of new and novel molecules, materials and treatments.
- Make barren or depleted lands productive. Mitigate human-induced and natural threats to the environment.
- Practically unlimited capacity for long-term data storage.
- Increased variety of cheaper, more nutritious foods created with lower environmental impact.

**APPLICATION**
- **DIGITAL HEALTH / PERSONALIZED MEDICINE**
  - Tailored medical treatments using AI to combine data from genetic sequencing, diagnostics, and biomonitoring.
- **ON DEMAND MEDICINE PRODUCTION**
  - Cell-and gene-based therapies, combined with improvements in drug design and production, for faster disease response.
- **BIOPRINTING AND XENOTRANSPLANTATION**
  - Additive manufacturing to “print” biological parts for medical testing or tissue replacement, grow human-compatible organs in animals for transplantation.
- **REPRODUCTIVE ENGINEERING**
  - Using genomic technologies to select and modify human embryos for broad range of traits and abilities.
- **COMPUTER-HUMAN INTERFACES**
  - Machine augmentation of human cognitive processes.
- **BIO-MANUFACTURING**
  - Bio-design and production of enhanced or highly specified materials, medicines and foods.
- **SYNTHETIC ORGANISMS**
  - Genetically modified organisms and biological processes create new materials and medicines.
- **ENVIRONMENTAL RESTORATION**
  - Large-scale ecological intervention, through biotechnology, reforestation, or ocean engineering creates, manipulates, or rescues damaged environments.
- **DNA-BASED DATA STORAGE**
  - DNA used to encode and store data.
- **TRANSFORMED AGRICULTURE AND FOOD PRODUCTION**
  - Automated precision production processes and integrated crop-livestock systems use genetically altered organisms.

**RISKS**
- Access disparities due to costs or location. Personal health data misuse or manipulation.
- Disputes over R&D prioritization in developed vs. developing countries.
- Access disparities due to the high up-front costs.
- Ethical and social divides over applications. Unequal access.
- Tensions between augmented and non-augmented individuals. New cyber/bio vulnerabilities.
- Increased potential for misuse and workforce restructuring.
- Potential for weapons applications or accidental misuse. Unknown environmental impacts.
- Unintended, potentially global environmental or public health consequences.
- Increased potential for long-term social monitoring.
- Reduced biodiversity, social tensions over genetic modification, workforce and supply chain disruptions.